Blockchain Based Framework and Approach for Global Healthcare System

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1. INTRODUCTION

Recently cryptocurrency has attracted intensive attentions from each trade in the world. Bitcoin that's usually referred to as the primary cryptocurrency has enjoyed an enormous success with the financial market 2016. The core principle technology that is underlying bitcoin is the Blockchain. Blockchain was first projected in 2008 and enforced in 2009 by Nakamoto.[1] Blockchain technology will be impacting nearly each side of digital lives in future, from the method of sending cash in terms of cryptocurrency to the method of managing data of different sectors may it be healthcare, property, energy utilization, insurance claims etc.. By preventing third parties intermediation, Blockchain promises to maintain equal rights of intellectual property. And if properly enforced, blockchain will create multiple technical systems with lot of reliability and security. Blockchain has borrowed its potential from the capabilities of distributed databases, cryptography, pc security, and scientific theory, to deliver a trustworthy and secure kind of shared information [7].Blockchain-driven information is replicated on multiple computers across several geographical areas being accessed by different users. Nowadays the blockchain technology is considered as the most significant invention after internet. Conceptually Blockchain could be considered as a distributed database of blocks where the records of information are shared among collaborating members. Every action is confirmed by the accord of a majority of members creating transactions unable to pass through the collective confirmation. Once a block is created and accepted by the blockchain it will never be altered or deleted. [2]

Although blockchain was first applied in financial trading through internet as it is the technology that allowed Bitcoin to work. But now it is an emerging technology to be applied in several industries like health care, insurance, pharmacy, producing, e-voting, legal contracts, tourism, energy, and travel trade.[4] The Internet of knowledge has been designed on protocols like TCP/IP for machine communication, hypertext transfer protocol for web page, SMTP for email, and FTP for file transfer. Blockchain facilitates trust and validates identity while not intermediate third parties, enabling a web useful. What TCP/IP has been for the exchange of knowledge, blockchain is for the exchange useful. The experts declared it well, blockchain “the trust machine”. [19]

1.1 BLOCKCHAIN TECHNOLOGY: AN OUTLINE

Blockchain may be considered as a distributed ledger in which the transactions that are in the commit mode are added to form a list of blocks. Each transaction is referred as block that is added in a chain like structure forming a blockchain. The crucial features of blockchain are decentralization, determination, obscurity and auditability. Blockchain is enabled by integration of many core technologies like Cryptographic hash, digital signature and distributed consensus mechanism.[1]

There are two types of Blockchains:

- Public: A public blockchain network is totally open and anyone will be part of and participate within the network. The network usually has associate degree incentivizing mechanism to encourage additional participants to affix the network. Bitcoin is one among the most important public blockchain networks in production these days.
- Private: Private Blockchains use Blockchain-based platforms running on personal cloud infrastructure. A non-public blockchain network needs to be authenticated by the initiator or the participants involved in the network having admin rights.

Intranet term could be the term used for private blockchain and internet could be the term used for public blockchain. Each user having distinctive identity would be categorized as permissioned blockchain user whereas anyone can participate in a permissionless blockchain. Users in permissionless blockchain does not need permission from any decentralized authority or central administrator to leave the network.[4] There are few important features of blockchain:[7]

- Collaboration
- Flexibility
- Resilience
- Distributed Verification

A blockchain could be considered as a mesh network of computers not connected to a central server rather to every node in the network. These nodes operate with a consensus mechanism along with data sharing in a secure and encrypted manner. Computers agree on a shared state of information. This shared state is a hashed Block in the Blockchain. Each block is added to the Blockchain in sequential order. Persons involved in block processing are called Miners who hash potential Blockchain blocks by using high amounts of computational power.

1.2 BLOCKCHAIN ARCHITECTURE

1. **Decentralized Network:** Blockchain architecture starts with a requirement of decentralized network in which different entities share data. It may be a Local Area Network for small scale applications or Internet for large scale applications. All the nodes are collaborating in Blockchain are connected to each other in decentralized p2p (peer to peer) network. Data is broadcasted in the network. But there are certain limitations of p2p network because of which, some applications have moved onto an enhanced network called cloud network. Blockchain developed on cloud is called Cloud Based Blockchain. [4]

2. **Encryption:** A Blockchain uses cryptography techniques to protect the data. Blocks uses a cascaded kind of encryption implies that encryption result or the hashed key of prior block will be generating the hashed key of current block. Security of the blockchain is enforced by cryptography in which each node generates its own pair of private and public keys.[4]

3. **Database over distributed network:** The database is of distributed nature in Blockchain technology as data is scattered among different computers in the network. There is no central node that controls the data in fact each node has full access to the whole database on the blockchain or required information. Although blockchain is having decentralized architecture so no central authority is required yet the trust and security is maintained by consensus mechanism.[4]

4. **Enforcing transparency:** The transparency is the key of blockchain which is implemented using pseudo-anonymity i.e users have a choice to remain as anonymous or no name user. Each user or node on a blockchain is identified by a unique alphanumeric 30-plus-character address.[4]

5. **Immutable records:** Once a block is created in the blockchain and information is inserted in the database, the records become immutable. A proper ordering is applied to these records and also records are made available to every node in the network.[4]

A list of blocks is created that are sequential. Every block in the list is referring to its parent block using the pointer as hash key. Child blocks are also saved in the blockchain using forward referencing hashed keys. A Genesis block is the first block of the blockchain which has no parent block. Every Block consists of Block header and body comprising of data (transactions), hash key, timestamp, parent block key etc. A combination of secret and public key is held by every participant in the network. The block information or data is signed using the secret key. Every user within the network can access these digital signed blocks that are distributed throughout the network. There are two phases of digital signature process: the signing phase and the verification phase. A process in which every node in the blockchain takes part in the validation of block information is called consensus determination. Every node can participate in consensus process in a public blockchain but in a consortium blockchain only few special nodes can validate the blocks. In a private blockchain the validation process for consensus determination can be done by a centralized node only.[1]

1.3 INNOVATIVE USE CASES OF BLOCKCHAIN

1. **Financial Risk Management**: An important factor in the financial industry is the risk management but it can be efficiently implemented using Blockchain technology.[1] Cryptocurrency was the primary blockchain application. Bitcoin gave the individual full possession over money in the digital form. It not only does the transfer of money but also a lot of complicated dealings can be configured into a cryptocurrency platform that could replicate traditional processes of economic dealings in the form of stocks, loans and bonds.[7]
2. **Healthcare:** A revolution is required in the healthcare system. Healthcare sector is resistant to immoderate drug costs, tampering, fraud, or political management. The name of the technology that can provide solutions to all these issues is blockchain. Blockchain can be indispensable in building a global healthcare system that optimally connects patients, clinicians, researchers, insurers and clinical laboratories to one another. AI and blockchain based frameworks can enhance the ways the healthcare records are managed and interoperated. Blockchain can improve the data security, medical claims management , R&D processes in the healthcare domain.[8]

3. **Energy**: Blockchain technology can seemingly modify the way electricity is bought and sold-out. At the sting of the grid—where electricity dead-ends in our heaters and appliances—consumers are setting out to manufacture their own electricity. Blockchain technology might offer the simplest way. Blockchain platform will seemingly take some role in substitution the systems that currently manage the distribution of electricity.[7]
4. **Identity:** Blockchain applications are projected that permit users to manage accounts containing numerous fragments of their identity. Within the future blockchain-based identity management solutions are projected for emergency cases of identity verification by WHO for finding the country of origin or to simply recover their records within the case of emergencies.[7]
5. **Internet of Things(IoT):** The most prominent technology is Information and communication technologies (ICT) that is ramping up recently. IoT is planned to integrate the items (also named sensible objects) into the web and provides users with varied services. Blockchains may additionally offer the way to manifest users across multiple IoT devices and to secure sessions [1]. For controlling of edge nodes in a distributed IoT architecture there is an executive process implemented using the Fabric distributed ledger.Also information from IoT wearable devices can be integrated into healthcare applications using blockchain.[7]
6. **Land registration:** One of prominent use case of blockchain could be land registration during which the land data like the physical standing and connected rights are often registered and advertised on blockchain. Besides, any changes created on the land, like the transfer of land or the institution of a mortgage are often recorded and managed on blockchain consequently improve the potency of registration process.[1]
7. **Drug Development**: Blockchains will facilitate the improved techniques for the new medicine development as patient's information is widely accessible. The problem of counterfeit medicines has become progressively pressing issues as involvement of black market implying the risk to human life that comes from taking counterfeit medicine. Blockchain technology is a superb counter to threats that area unit quickly approaching (integrity-based attacks) and it's a decent progressive tool that would be deployed to deal with these issues.[4]

2. REVIEW OF LITERATURE

ZibinZheng et.al.(2018) gives an outline of blockchain and its component functioning. Comparison of consensus algorithms is done and applications of blockchain in various industries are listed. At last the future trends and innovative use cases are also elaborated. Although the technology is new and trending yet it also has some limitations like scalability which is could be a hindrance when blockchain is implemented for a very large scale system.

Dimitry Efanov et.al (2018) illustrates the all-pervasive nature of blockchain technology. Three phases or generations of the block chain development are highlighted in this research: Blockchain1.0 as digital currency, Blockchain 2.0 as digital economy, and Blockcchain3.0 as digital society. This paper abridges unmistakable use instances of the blockchain innovation including cryptographic money, IoT, communication among machines, electronic health records, unique identity generation, smart communities and contracts.

James Brogan et.al.(2018) expounds the way electronic ledger in a distributed manner can assume a key job in progressing electronic health records , by guaranteeing credibility and uprightness of information produced by wearable gadgets. Additionally exhibited the veiled confirmed informing module can be utilized to safely share, store and recover encoded movement information utilizing sealed appropriated record.

Matthew N. O. et.al. (2018) introduces blockchain technology, technical aspects and types. It also discusses the various applications in healthcare industry like record management, clinical drugs, drug management and security concern. Author has discussed the main benefits of blockchain i.e. interoperability and data security. At last author concluded with various challenges of blockchain technology.

William J. Gordon et.al.(2018) depicts two kinds of interoperability : organization-driven and person-driven. Organization driven interoperability which has been the primary focal point of interoperability endeavors, depends on various entities involved in healthcare industry trading health information depending on business endeavors. There has been an expanding move towards person-driven interoperability in which individual’s digital health information is made accessible to them through standard components like GUI’s blockchain innovation, by making a stage for the protected trade of information is an appealing strategy for tending to difficulties of person-driven interoperability.

Peng Zhang et.al.(2018) proposed a blockchain based design for clinical information sharing : FHIRChain. It indicates creation and recovery of an entrance token utilizing FHIRChain. FHIRChain is connected to make a model DApp. The center of application is coded in javascript that has an interface of Blockchain called Ethereum. Author concluded with the benefits of FHIR using case study of DApp

Morgen Peck et.al.(2017) elicited the IEEE initiatives and support for the Blockchain technology to be implemented in various sectors of public services like education , energy healthcare etc. Also author explained the important features of blockchain in various domains like every feature could act as a basis for the application of blockchain technology. Paper was concluded with various challenges of technology.

Axel Schumacher (2017) provided an integration of blockchain and healthcare. Healthcare sector could be reinvented using a global blockchain system. An ecosystem would be developed using this precision medicine system that could enhance the ways health care is provided to people. Author illustrated different existing systems available, their implications and applications in the industry of healthcare in different countries.

Liam Bell et.al.(2017) focuses on the current issues in the new ecosystem of healthcare like Exchange of health information, Global interoperability, Tracking of health gadgets, medicine management. Additionally the Blockchain arrangements (Microsoft's Coco, Deepmind, Medrec, IBM's Watson, IOT Device Tracker) utilizing concept proof instrument have been created which bring blockchain advancements into the medicinal services industry anyway there are as yet numerous obstructions to adoption.

Tsung-Ting Kuo et.al.(2017) introduces the bitcoin cryptocurrency architecture along with distributed ledger technology along with different hashing algorithms. The contrast of centralized network, decentralized network and blockchain is illustrated; recognized advantages of blockchain contrasted with conventional databases for medicinal services applications and gave an explanation of the most recent applications in healthcare and difficulties of blockchain in human services.

Peng Zhang et.al.(2017) gives the highlights and execution challenges in medicinal interoperability, a conclusion to-end contextual analysis of a blockchain-based human services application (DASH).Authors gave an outline of the blockchain stage and depicted the

inspirations for applying blockchain innovation to comprehend medicinal services interoperability issues, concentrating on keeping up resolvability while limiting incorporation multifaceted nature, limiting information prerequisites of storing data with security concerns and following important wellbeing changes crosswise over vast patients populaces.

Tareq Ahram.et.al.(2017) centers around a push to interfere with the base for introducing and exhibiting the work of blockchain innovation in different applications. Authors of this paper surveyed the guarantees from the viewpoint of cloud computing towards blockchain. The stages and components were ensured a solid structure on the prevention, disengagement and correction of digital security ruptures. Additionally this paper discusses on skilled responsibility of Blockchain technology on engineers for the new advanced digital devices.

Xueping Liang et.al.(2017) illustrates integration of blockchain with mobile healthcare applications. A mobile application will be introduced for the accumulation of wellbeing information from individual wearable gadgets, manual information and therapeutic gadgets. To synchronize information to the cloud for information imparting to medicinal services suppliers and medical coverage organizations. To protect the respectability of the wellbeing information inside each record a proof of uprightness and approval is for all time retrievable from cloud database and is moored to the blockchain organize.

Xiaoqi Li et.al.(2016) led a precise report on the security dangers to blockchain frameworks and study the comparing genuine assaults by looking at prevalent blockchain systems(Ethereum,Bitcoin,Monreao and so forth.).Highlighting the security attacks on the existing systems selfish mining, DAO, BGP hijacking, eclipse, liveness and balance.Concluded witth security enhancements as Smartpool, Quantitaive framework, Oyente, Hawk, Town Crier.

Juri Mattlia (2016) denoted the blockchain as a phenomenon of distributed consensus architectures. Starting from an elaborated explanation of Blockchain technology moving towards specific blockchain solutions(ethereum, eris etc.) for the different applications of finance , nanopayments ,supply chain etc. Author has given deep insight into the implications of advanced trust reclassified, the pattern of disintermediation, democratization of store network, a move towards a robotization economy, reconfiguration of administrative limit.

Drew Ivan(2016) proposes a novel way to deal with secure wellbeing information storage, execution snags and an arrangement for progress steadily from current innovation to a

blockchain answer for US healthcare system. A venturing stone toward this objective is to execute a blockchain-based PHR where, utilizing existing Use models, approved substances get duplicate of patient information.

Dr., Bethesda (2016) centers that Blockchain will assume an undeniably noteworthy job in medicinal services IT and convey useful interruption and new efficiencies to each partner in the environment. To guarantee the similarity and interoperability of frameworks, full potential of blockchain technology must be identified. Highlighted the promising use cases of blockchain in healthcare

i) Identity Verification ii) Medical Banking iii) Counterfeit Drug Prevention and Detection

iv) Population Health Management v) Genomics Research vi) IoT and Blockchain

vii) Validation and Payment of Claims viii) Clinical Trial Results ix) EMR x) Doctor-Vendor RFP Services

Asaph Azaria et.al.(2016) proposes MedRec: a novel ,decentralized record management system to handle EMR's using blockchain technology. The block content represents the owner of data and viewer permissions shared by participants in the network. Blockchain innovation bolsters the utilization of smart contracts which enable us to mechanize and follow certain state advances via smart contracts.

Steve Huckle et.al.(2016) focuses on the use of IoT scenarios embedded in blockchain for shared economy applications. Shared economy applications like AirBnb and Uber are best candidate for integration of IoT and blockchain. There can be a myriad of sharing applications like p2p automated pay systems, foreign exchange platforms, digital rights management etc. Proposes different architectures being carried in their own Dapp for implementation to create a shared economy.

Matthias Mettler(2016) defines Blockchain as Revolution i)Bitcoin as a beginning stage for the improvement of blockchain ii)Blockchain potential reaches out a long ways past the finance related segment iii)Smart medicinal services the executives to assist the patient iv) Blockchain enables end clients individually patients

Jesse Yli-Hummo et.al.(2016) summarizes all the research that had taken place and the current research work in the blockchain technology. Also analyses the over impacts and hype of the technology the including the challenges and solutions with respect to blockchain. At last author concluded with the research gaps and future research perspectives of blockchain.

Xiao Yue et.al.(2016) proposed an application HGD(Healthcare Data Gateway) engineering dependent on blockchain to empower patient to possess, control and offer their very own information effectively and safely without damaging security which gives another potential method to enhance knowledge of medicinal services frameworks while keeping quiet information private. This reason driven access demonstrate guarantees patients possess and control their healthdata; straightforward brought together Indicator Centric Schema(ICS) makes it conceivable to sort out a wide range of individual health information for all intents and purposes and effectively.

J. Leon Zhao et. al.(2016) gives an overview of blockchain innovations in business sector. Illustrates the way bitcoin currency is being handled in the digital form. The ongoing blockchain related endeavors included blockchain by Fadada.com and Microsoft, Port following blockchain by Walmart and IBM. Diagrams inquire about circumstances in investigating and approving blockchain applications in various segments and important orders.

2.1 RESEARCH GAP ANALYSIS

The following research gaps have been identified after analyzing the relevant published literature:

1. Blockchain has impacted only the financial applications sector but not much focus has been given on basic public service applications.
2. Various frameworks have been designed for handling healthcare data but there is no mechanism for a universal single copy for patient health record.
3. There is no system to manage health data online and to handle interoperability of health data. The system is still hanging only on EMR’s (Electronic Medical Records).
4. Enhanced Consensus mechanism needs to be implemented in the system for the validation and authentication of health data in the distributed network.
5. Critical health Data must be safe and secure. Hence, improvised encryption algorithms need to be included in the system.

3. RESEARCH METHODOLOGY

Research is a systematic investigation of a subject or a problem in order to discover relevant information. Research Methodology comprises of procedures or techniques used to identify, select, process, analyze the data for the establishment of theories, deducing facts and generating conclusions. Every research starts with identification of the problem as initial step followed by defining objectives, research design, data collection, analysis and interpretation of data by applying different tools and techniques and at last verification and validation of results is conducted. Section 3.1 formulates the problem statement on which the research is to be conducted. Section 3.2 gives the formal description of research objectives. Section 3.3 signifies the scope of the study and Section 3.4 briefs the research method.

3.1 PROBLEM STATEMENT

The formulated problem is entitled as "Blockchain Based Framework and Approach for Global Health Care System." In healthcare sector EMR's (Electronic Medical Record's) is the only existing system for managing health data for patients in India but that also only in corporate or private hospitals. These EMR's are accessible intra hospital i.e within the hospital only. Patients have to maintain hard copies of their health records for future use. There is no global system for managing health records in the present system. Also the problems of interoperability i.e handling different formats of data and their exchange , critical health data security and privacy is very crucial for the healthcare industry. After consideration of the above cited problems, it becomes pertinent to conduct the present study which encompasses providing a novel framework for handling critical issues of global health care system using a revolution technology called BLOCKCHAIN.

3.2 RESEARCH OBJECTIVES

1. To study existing techniques and applications of Blockchain Technology.
2. To identify issues and loopholes in the existing blockchain systems.
3. To design a model for the generation of an identity to access health data.
4. To develop a novel blockchain framework for management and exchange of heterogeneous data.
5. To propose new techniques for enhancing consensus mechanism.
6. To improvise encryption algorithms to provide secure and immutable records.
7. To compare and validate proposed framework with the existing healthcare systems.

3.3 SIGNIFICANCE OF STUDY

This research shall bring prominent changes in the way health care industry operates in India. A Blockchain based global health care system will enhance the management of health data in terms of accessibility without networking constraints as data will be stored on the distributed ledger blocks on the network which can be accessed in any hospital using a unique patient id and joint consensus mechanism of patient and other entities. Data can be maintained by both patients and other entities involved in the system.

Critical health information will be secure and tamper proof as blockchain uses very strong key cryptographic and hashing techniques. In this research some enhancements on the encryption and security techniques shall also be proposed for this critical information. At last this framework could be profoundly used for the purpose of medical research.

3.4 RESEARCH METHOD

A research method indicates the process in which the research will be carried out. It will specify the research methodology used in the study. In order to bridge the research gaps a systematic study is required that will propose a novel approach towards implementing blockchain in health care sector. Proposed framework will be the core application of computer science in health care IT using Blockchain and Distributed databases. A comprehensive literature survey will be conducted and then the framework will be applied on real time data for the validation of the research conducted. The aim of the presented study is to provide an empirical research methodology for integrating blockchain technology in healthcare IT sector providing practical solutions to the issues of data syndication, interoperability and security of critical health information.

Proposed Framework:

The framework will be divided into four components:

1. **Creation of Block:** When first time the information is entered a new block will be created.

2. **Generation of Patient identity:** Once the block is created a unique key for patient will be generated that will act as a primary key in the distributed database. This identity or key will only be used for accessing patient records globally.
3. **Data Management and Interoperability:** The information regarding the patient health record like symptoms for the diseases, prescriptions, x-ray reports, lab reports etc. will be inserted into the database and the new block with hashed key would be appended into the blockchain. Once a block is created it becomes immutable i.e cannot be deleted. The interoperable data could be shared by any node with due permissions.
4. **Consensus and Security Checking Module:** If an existing record is to be searched or shared it has to be validated using patient hashed key and a joint consensus of doctor/hospital and patient. Encrypted key ensures that each block having critical health data is secure in the blockchain and no one can access without permission.

3.5 CHAPTERIZATION

Chapter 1: Introduction

An Introduction to the blockchain technology will be elaborated in this chapter. It covers the basic working, underlying principles of blockchain architectures including the distributed ledger technique, smart contracts, consensus algorithms and security mechanisms like key cryptography and hashing. At the end an insight into application areas of Blockchain technology will be given.

Chapter 2: Review of literature

This chapter will review the relevant literature of the research work directly or indirectly from various sources such as reference books, journals, periodicals, research oriented user groups and internet.

Chapter 3: Research Methodology

An insight into the research methodology will be given in this chapter. It comprises of problem statement, research objectives, scope and significance of the study, research design, analysis, chapterization and limitations of the study.

Chapter 4: Issues and Loopholes in Blockchain Systems

This chapter will be identifying and dealing with the issues and loopholes present in the existing blockchain systems. Various disruptive mechanisms will be discussed with respect to current blockchain systems in practice.

Chapter 5: Blockchain Framework for Global Healthcare System

A model will be designed for the generation of an identity to access health data. Also a novel blockchain framework shall be proposed for managing and exchange of heterogeneous data. The proposed framework shall be providing solution to the issues and loopholes identified in the previous chapter.

Chapter 6: Data Blocks validation using Enhanced Consensus Algorithms

This chapter will be proposing enhanced consensus algorithms for the blocks validation and uninterrupted access of information in the blockchain framework designed in previous chapter.

Chapter 7: Encryption of immutable records

A detailed explanation on Encryption techniques for health care data will be given in this chapter. Also implementation of improvised hashing and cryptographic keys in the proposed framework will be illustrated.

Chapter 8: Validation and Performance comparison

This chapter will be validating the proposed framework of blockchain technology for health care system on the basis of real time health data. The performance comparison of both proposed blockchain system and traditional systems shall be discussed in this chapter.

Chapter 9: Conclusion and future scope

Finally, this chapter shall be devoted to the concluding remarks and future prospects of the present work.

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